Air Force Material Command

War-Winning Capabilities … On Time, On Cost

Low Temperature Cure Powder Coating

ESTCP PROJECT WP-0614

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Overview

- Powder Coating Process
- LTCPC Material
- ESTCP Project
- DoD Benefit

What Is Powder Coating?

Coating material in solid state which either melts during the application process, or cures at elevated temperatures subsequent to application.

versus

Traditional wet coating materials which are borne in solvent solutions that must evaporate off in conjunction with curing.

Process (Application)

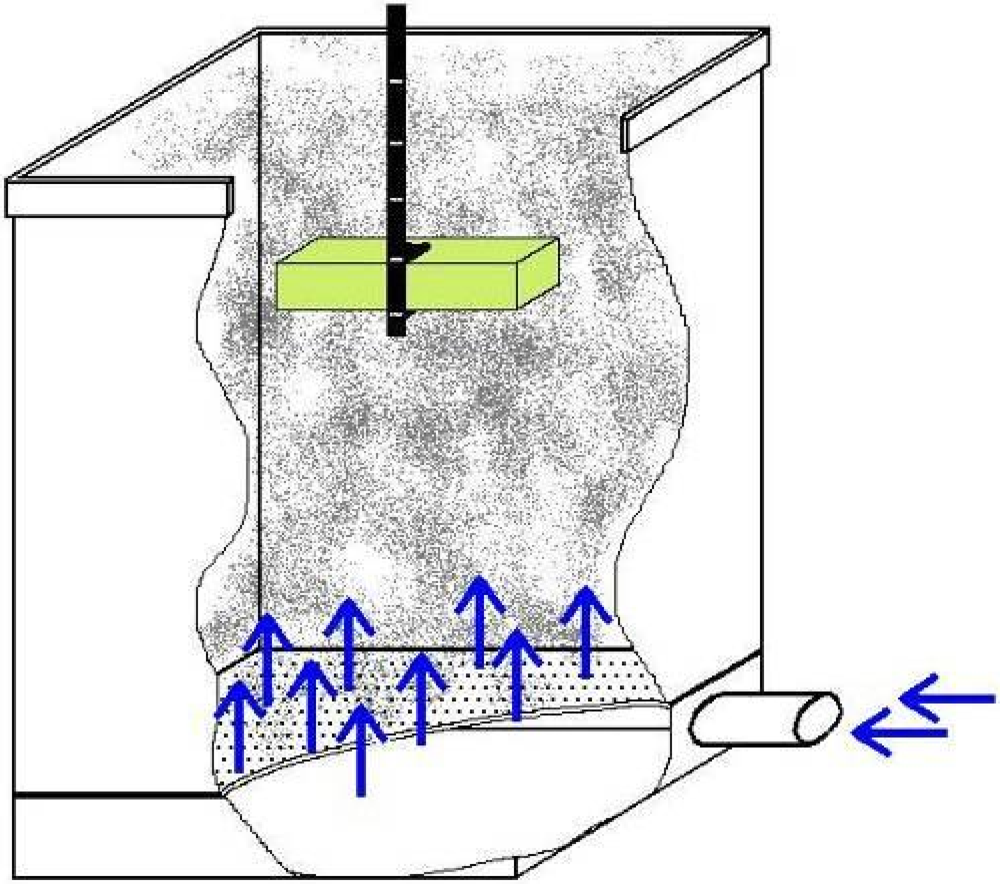
Powder Coating Application Technologies

- Fluidized Bed
- Electrostatic Fluidized Bed
- Tribomatic Gun
- Corona Gun

Fluidized Bed Method

Parts are pre-heated and suspended in an airborne cloud of powder coating material.

- Benefits:
  - Simplicity
- Limitations:
  - Only coatings 10-100 mil are possible
  - Coating thickness control is difficult
  - Require moisture/humidity control
  - Substantial energy required to preheat parts
  - Not used to a significant degree today



Electrostatic Fluidized Bed Method

Similar to standard fluidized bed system, but powder is electrostatically charged and part is grounded so that particles are attracted to part surface.

- Benefits
  - Preheating of part not required
  - 4-10 mil thickness of coating is possible
  - Small parts coated uniformly, quickly
- Limitations
  - Inside corners tend to receive low film thickness due to Faraday Cage Effect
  - Part size is limited by container size
  - Requires moisture and humidity control
  - Usage is not as common as in the past

Tribomatic Gun Method

Powder is applied using hand-held gun designed to impart an electrostatic charge through friction between powder particles and gun internal material.

- Benefits
  - Even layer deposition
  - Improved deposition into recesses
  - Gun does not produce the Faraday Cage Effect
  - Typically consumes 20% less powder than Corona Gun
- Limitations
  - Coats at half the speed of corona gun
  - Electron donor/acceptor tendency between powder and gun material must be great enough for adequate charging of the powder
  - Operation is sensitive to moisture and humidity

Corona Gun Method

Powder is applied using hand-held gun featuring a high-voltage electrode at the front end. The electrode creates ions, which impart a charge to the powder particles exiting the gun, and the charged particles are attracted to the electrically grounded target part.

- Benefits
  - Low film thickness possible (1.5 - 5 mils)
  - Newer gun designs have mitigated much of the Faraday Cage Effect
- Limitations
  - Still some difficulty to cover deeply recessed areas due to Faraday Cage Effect

Why Powder Coat?

- Elimination of VOCs
- Elimination of HAPs
- Reduction of ESOH Concerns
- Reduction of Hazardous Waste
  - Single component, solvent free material – no pot life limitations
- Process Efficiency
  - Quick cure time
  - Quick equipment prep and clean-up

Why Not Powder Coat?

- Processing temperature is high
  - Fluidized bed – parts preheated as high as 675°F
  - Coating cure temperatures – typically as high as 428°F
  - Prohibitive for use on some common alloys
- Earlier powder coating technologies provided barrier protection only and compromised coating did not inhibit corrosion

SERDP Material

- Low Temperature Cure Powder Coating
- SERDP Project WP-1268
- Completed in January 2005
- Developed to address deficiencies of conventional powder coating materials

SERDP Project of the Year 2004

SERDP Material

- Accomplished by GE Global Research, Crosslink Powder and DoD Labs
- Program Results - developed a viable low temperature cure coating
  - Coating cures at 120°C within 30 minutes
  - Corrosion resistance comparable to current coating systems
    - Barium metaborate corrosion inhibitor package
  - Coating does not require a primer
  - Coating met all target performance requirements

SERDP Material

Property	Test		Requirement	Low Temperature Cure Powder	MIL-PRF-85285 Polyurethane Topcoat
Adhesion	Crosshatch		4B	5B	5B
Flexibility	Mandrel Bend (Dia.)		¼”	Pass	Pass
Corrosion Resistance	Salt Fog 2,000 hrs (Undercut Rating)		10	10	10
Toughness	G.E. Impact (% Elongation)		5%	5	40
Hardness	Pencil		2H	3H	HB
Chem Resistance	MEK Double Rub		25	117	174
	Hydraulic Fluid 1 (Δ Pencil)		0	0	0
	Hydraulic Fluid 2 (Δ Pencil)		0	0	0
Cleanability	MIL-PRF-85285D (% Contaminate Removal)		75%	87	95
Weathering	Xenon-arc (500 Hrs)	Δ Gloss	10	4	6
		Δ Color	2	0	0
Gloss	60º Specular Gloss		90	90	94
Surface Quality	DOI Wavescan, Calibrated to PCI Standards		4	4	8

SERDP Material

- Material Advantages
  - Met all military ground support equipment requirements for durability, toughness, chemical resistance, gloss, and surface quality
  - Cleanability verified using QPL cleaners
  - Complete field repair evaluation performed
  - Weathering and filiform corrosion tests performed
- The Final Product
  - Acid functional polyester resin and catalyst with triglycidylisocyanurate (TGIC) crosslinker and a barium metaborate type corrosion inhibitor package

ESTCP LTCPC Project

Taking the Coating to the Next Level – Transitioning the corrosion inhibiting, low temperature cure powder coating to the field.

This will occur through an ESTCP funded effort.

Primary Performers:
- AFMC
- OO-ALC
- U.S. NAVY
- SAIC
- CTC
- Crosslink Polymers

Stakeholders:
- NASA
- U.S. ARMY
- Air Force Corrosion Office

AF Demonstration Location

Ogden Air Logistics Center
(OO-ALC)

Hill AFB, UT

- Maintenance and repair facility for aircraft components and Gearbox refurbishment
- Depot wide effort to reduce wet application
  - Buy-in of LTCPC from production level staff and process engineers
  - Goal is zero VOC/HAP

Gearbox Assembly

Navy Demonstration Location


Tow Bar

NAS Whidbey Island, WA

- Maintenance and repair facility for support equipment
- Depot wide effort to reduce wet application
  - Buy-in of LTCPC from production level staff and process owning engineers
  - Goal is zero VOC/HAP, Cr^{+6}


AN/ALQ-99 Pod WRA Universal Sling Assembly

Project Description

- Demonstrate/Validate
- Implement

Technology Transition
- Prepare Final Cost Benefits Analysis and Final Test Report
- Update military specifications
- Update Technical Orders and Maintenance Manuals

Coating Field Demonstration
- Validate robustness of system in operational environment
- Apply LTCPC to operational parts
- Field Service Evaluation - compare performance versus baseline data

Coating Performance Validation
- Limited material testing (JTP) - OO-ALC, NAVAIR Patuxent River, MD, CTC
- Facility preparations / Equipment installation
- Assess Demonstration Plans

Requirements Collection and Assessment
- Develop Joint Test Protocol
- Site Surveys - confirm service or process specific requirements: Level I ECAM
- Develop Demonstration Plans
- Procure Equipment

Project Aspects

Application Procedure

- Clean
  - Traditional methods
- Surface preparation
  - Traditional methods
  - Navy interest in hexavalent chrome-free materials
- No Primer Application
  - Chrome elimination
  - VOC/HAP elimination

- Powder Application
- Cure
  - 120ºC
  - 30 minutes

Project Aspects

Preferred Application Methods

- Primary candidate is the ITW GEMA OptiFlex corona gun
  - Suitable for candidate hardware featuring complex configurations

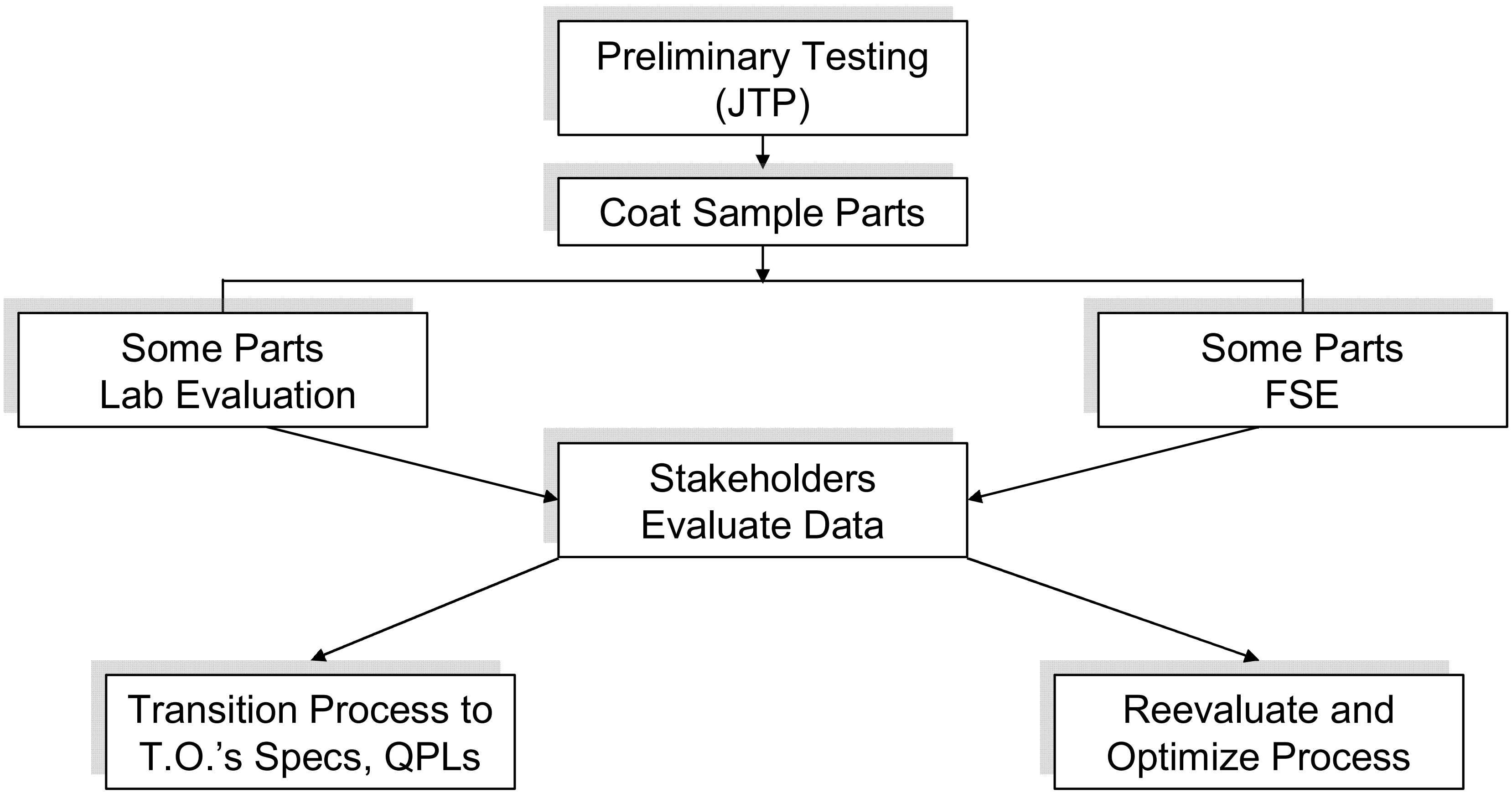
Unlikely Application Methods

- Electrostatic fluidized bed promising, may be commercially unavailable
- Fluidized bed unlikely to produce coatings within desired thickness limitations
- Tribomatic gun requires substantial humidity and moisture control

Project Aspects

- Joint Test Protocol (JTP) completed
- Lab level (coupon) testing to "qualify" coating on various substrates
  - Stakeholder identified critical performance requirements
    - Corrosion Resistance
    - Flexibility
    - Adhesion
    - Appearance
  - Aluminum, magnesium, steel substrates

Project Direction



Technology Transition Plan

- Develop Qualified Products List (QPL) for MIL-PRF-24712
- Update T.O. 1-1-8, Chapter 8 with LTCPC procedure
- AF Form 202 – Process Order Change Request for Air Force process changes
- Navy manuals NAVAIR 17-1-125 and NAVAIR 01-1A-509
- Cross feed/presentations/trade journals
- Equipment will remain in full rate production

Expected DoD Benefit

- **Environmental Savings**
  - 2,000 gallons paint annually – 2,820 lb VOCs
  - 1,200 gallons paint thinner – 8,280 lb VOCs
  - Reductions in hazardous waste
- **Economic**
  - Materials Savings - $111,760/yr
  - Labor Savings - $253,440/yr
  - Waste Disposal Savings - $15,000/yr

SUMMARY

A powder coating material that will allow us to overcome previous limitations of the powder coating process resulting in:

- VOC, HAP and solvent free coating
- reduced labor hours
- lower costs